U.S. DEPARTMENT OF ENERGY
Office of Science

Office of High Energy Physics

Program Status

Cosmic Frontier Symposium
March 26, 2011 at Fermilab

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Office of High Energy Physics
DOE Office of Science

DOE Office of High Energy Physics Program

Overall Program & Budgets

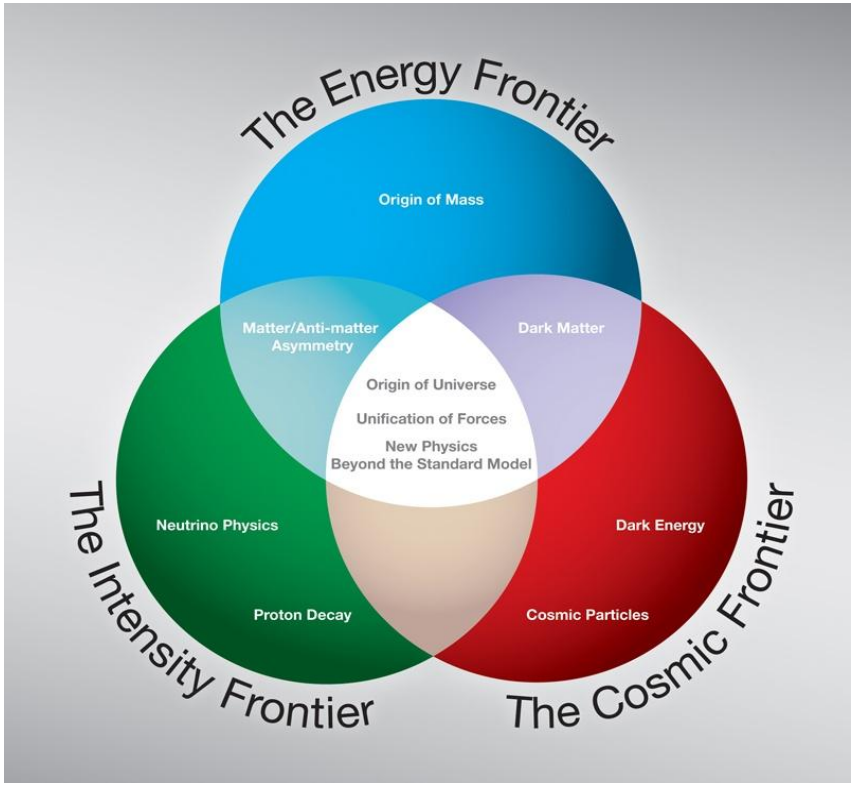
The Cosmic Frontier

High Energy Physics Program - Scientific Frontiers

- ***The Energy Frontier*, powerful accelerators are used to create new particles, reveal their interactions, and investigate fundamental forces;**

- ***The Intensity Frontier,* intense particle beams and highly sensitive detectors are used to pursue alternate pathways to investigate fundamental forces and particle interactions by studying events that occur rarely in nature; and**

- ***The Cosmic Frontier*, ground and space-based experiments and telescopes are used to make measurements that will offer new insight and information about the nature of dark matter and dark energy, to understand fundamental particle properties and discover new phenomena.**



The major elements of DOE's plan are to:

Exploit the capabilities of the Tevatron and LHC at the **Energy Frontier** to make discoveries
Implement a world-class **Intensity Frontier** program at Fermilab
Address compelling high-impact scientific opportunities at the **Cosmic Frontier**
Develop accelerator technologies needed by Nation and for a U.S. leadership role in particle physics

FY 2011 – We are in a Continuing Resolution

	FY 2010 Actual	FY 2011 Request	FY 2011 CR
HEP	**810,483**	**829,000**	**799,500**
SC	**4,789,288**	**5,129,574**	**4,826,000**

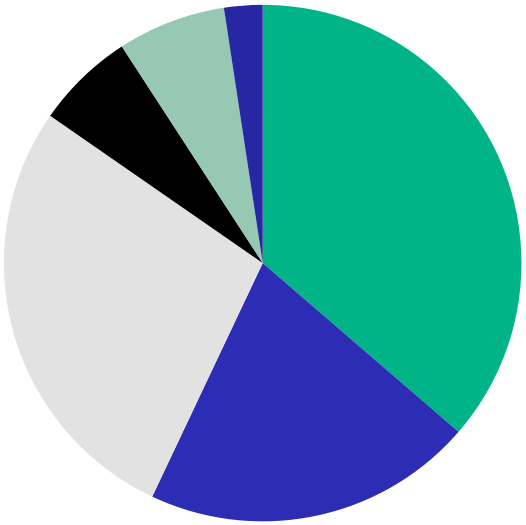
- We have been operating under a CR for almost 6 full months now.
  - We are below the FY 2010 level, since funds are being held back for new project starts.
  - The House just passed another 3 week CR with no change for SC.
  - **MicroBooNE, Mu2e, and LBNE are considered new starts and are not receiving any equipment funding, which includes PED for Mu2e and LBNE.**
  - **Long Continuing Resolution (again) has delayed funding of current grants and new grants are on hold.**

The President's FY12 Budget Request for High Energy Physics

Description	FY 2010	FY 2011 Request	FY 2011 March	FY 2012 Request	FY12 vs FY10
Proton Accelerator-Based Physics	438,369	439,262	439,462	412,707	-25,662
Electron Accelerator-Based Physics	30,212	24,707	20,805	22,319	-7,893
Non-Accelerator Physics	97,469	88,539	88,539	81,852	-15,617
Theoretical Physics	68,414	69,524	68,024	68,914	500
Advanced Technology R&D	156,347	189,968	173,346	171,908	15,561
Construction	0	17,000	0	39,500	39,500
Total, High Energy Physics	790,811	829,000	794,078	797,200	6,389

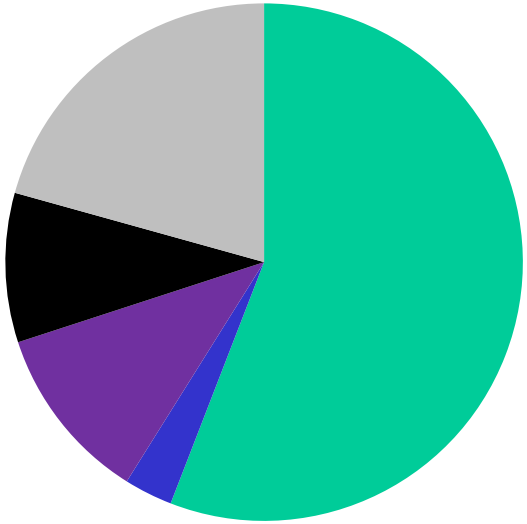
FY 2010 appropriation including SBIR/STTR was $810 million, so the FY 2012 request is a reduction of $13 million from FY 2010.

Cross cuts

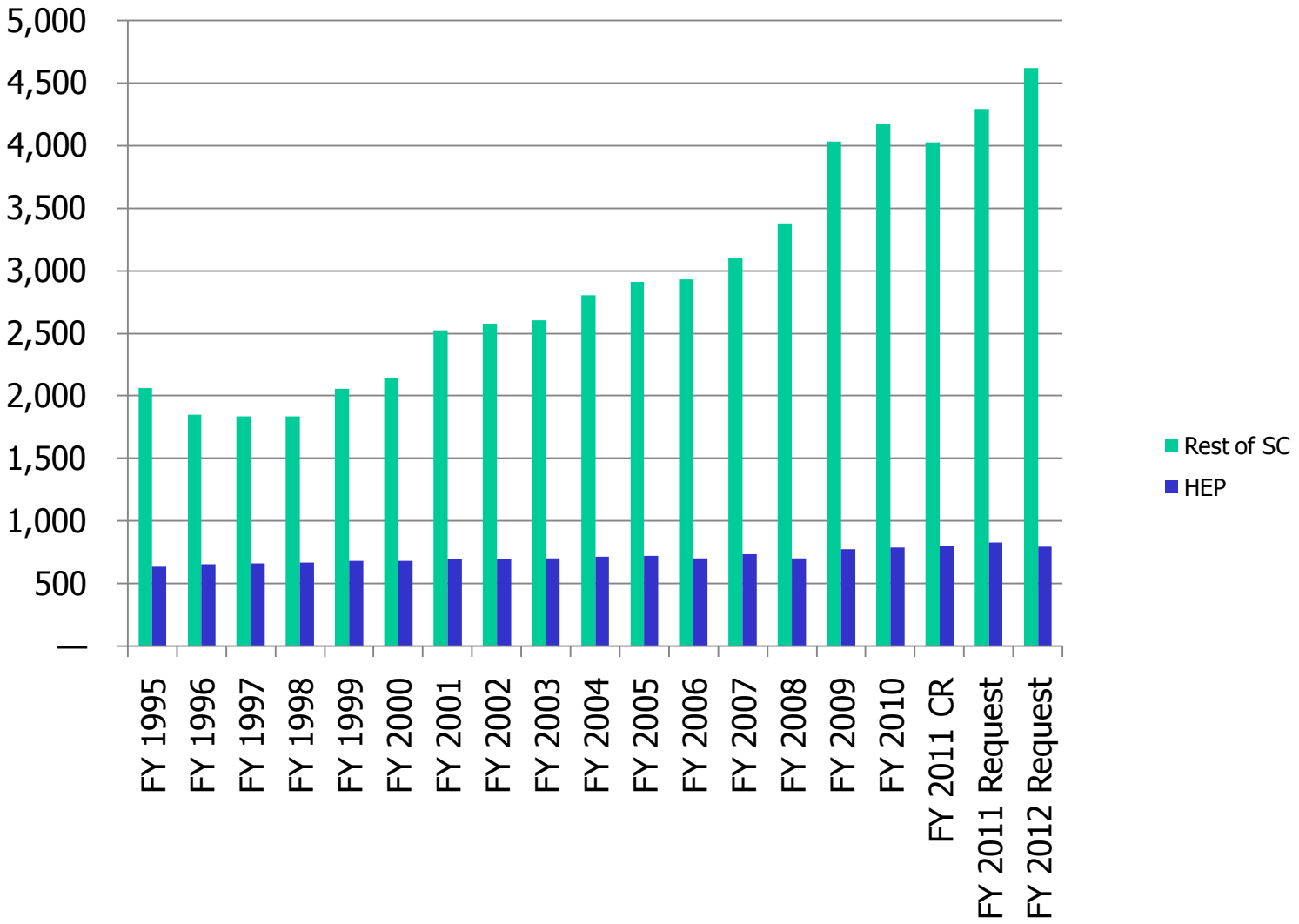


By function

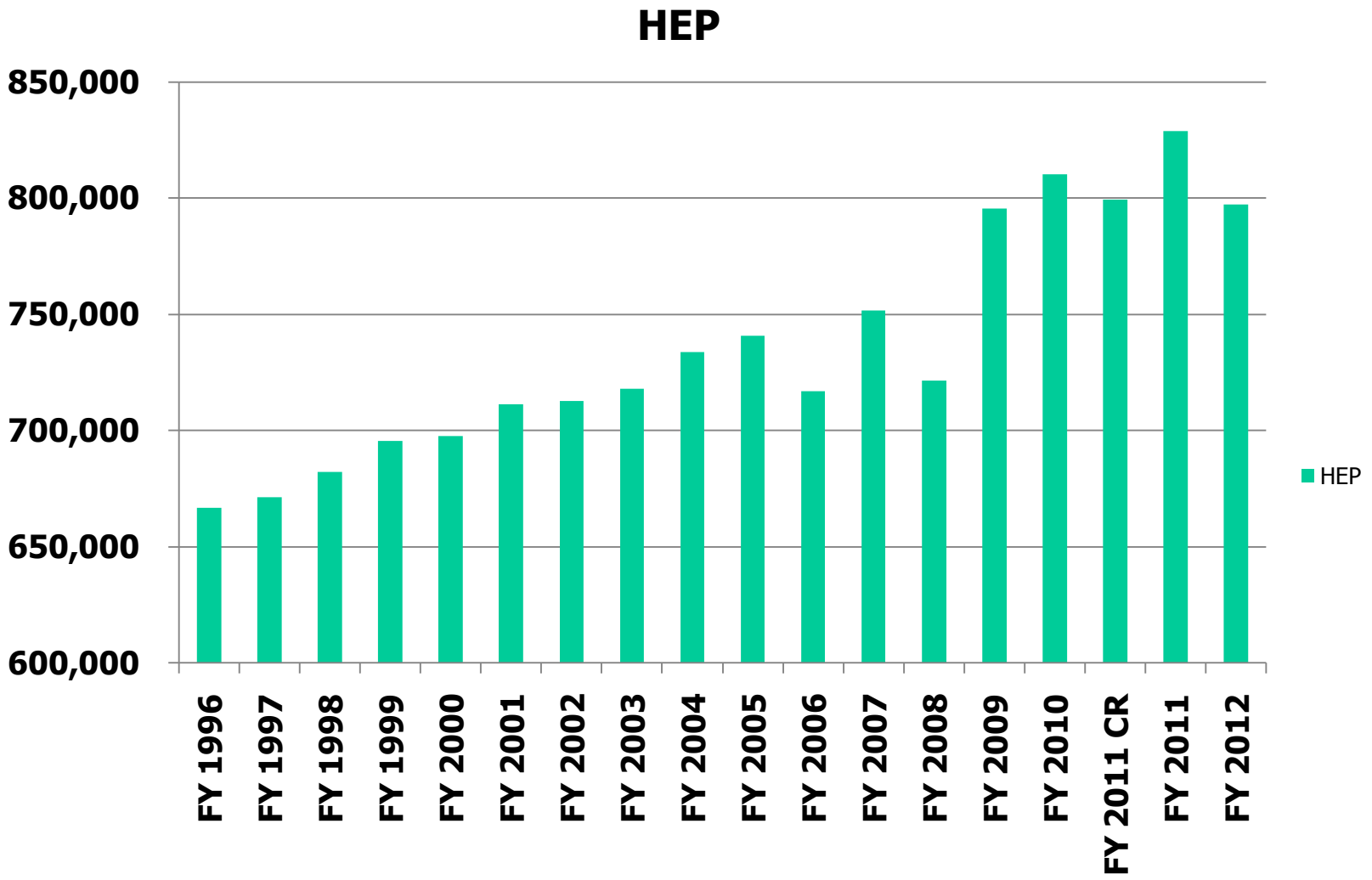
By program



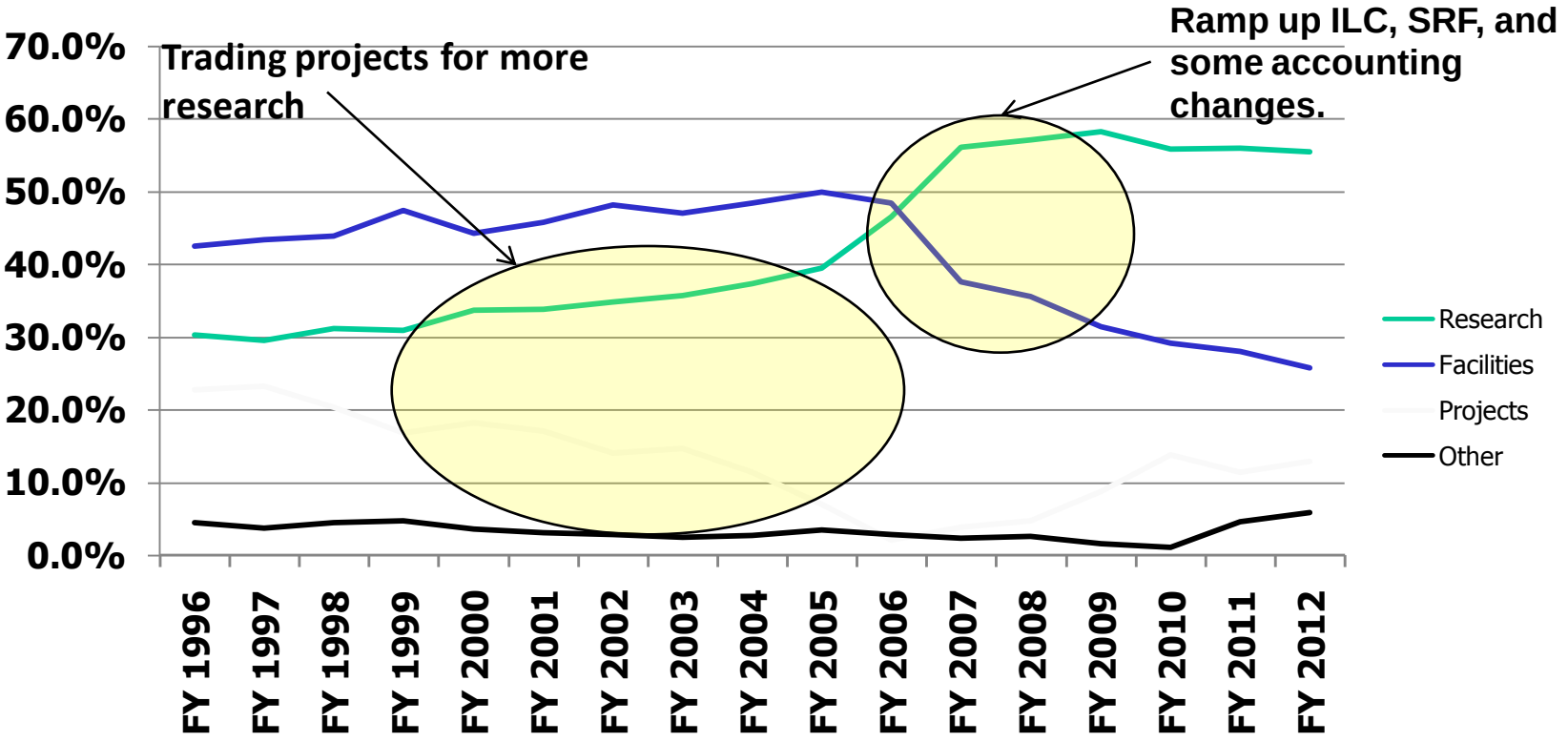
SC and HEP Funding Trends



HEP Funding History



Trends



- In the late 90's the fraction devoted to projects was about 20%.
- This fraction reached a minimum around 2006.
- The projects started since then are coming to completion.
- The HEP Committee of Visitors recommended projects should be ~20% of the budget.

FY12 Program

The Tevatron will not run in FY 2012.

- **HEPAP P5 subpanel evaluated a proposal for 3 more years of ops; recommended only extending the run if new funding could be found.**

LHC runs through 2012

The Fermilab accelerator complex will run in FY 2012 for 6 months to support the neutrino program.

Research in accelerator technologies including superconducting radio frequency and plasma wakefield acceleration.

Projects:

- **The NOvA project will install the first detector modules and the required accelerator upgrades in FY 2012; will complete in FY 2013**
- **Mu2e and LBNE start construction in FY12**

  Work on both projects has been slowed to prevent a gap in funding.

- **The Reactor Neutrino Experiment at Daya Bay in China and the Dark Energy Survey in Chile begin operations in FY 2012**
- **The DOE scope on the High Altitude Water Cherenkov (HAWC) experiment begins fabrication**

Intensity Frontier: DUSEL

DOE and NSF had developed a partnership model for the physics program at the Deep Underground Science and Engineering Lab (DUSEL), which would be in the Homestake Mine in Lead, South Dakota.

- **DOE HEP would steward the Long Baseline Neutrino Experiment (LBNE) while NSF stewarded the DUSEL Facility.**
  - DOE HEP would lead the construction of the neutrino beam, near detector, far detector, and the underground cavern for the far detector.
  - NSF would contribute a fixed dollar amount to the far detector and the underground cavern for the far detector.
  - NSF would provide the non-detector specific infrastructure such as the shafts, water pumping, ventilation, etc.
- **NSF would steward the dark matter experiments and DOE HEP would partner.**
- **DOE NP would steward neutrinoless double beta decay and NSF would partner.**

Davis cavern refurbished by South Dakota.

- **The National Science Board rejected this arrangement and declined to fund the DUSEL project any further.**
  - NSB suggested that this was more appropriate for DOE to build the facility.

Intensity Frontier → Where we go from here

- **The Office of Science has an interest in three experiments that had been planned for DUSEL.**
  - Long Baseline Neutrino Experiment
  - Dark Matter
  - Neutrinoless Double Beta Decay
- **The Office of Science has started a review process to assess impacts and viability if any of these can be carried out in a cost effective manner at the Homestake Mine.**
  - Review Chairs: Jay Marx, Mark Reichanadter; First meeting mid-April
  - Stakeholders were informed of the review process at the end of February.
    - Government of South Dakota
    - Universities and national labs that were involved with DUSEL.
    - Leaders of scientific collaborations that hoped to work at DUSEL.
- **The FY 2012 request includes $15 million to keep the Homestake Mine viable while decisions are made. (HEP $10 M, NP $5M)**

  Will maintain the viability of DUSEL, including dewatering and maintaining security, while DOE assesses options for an underground research program.
- **Review process will inform the FY 2013 request.**

Non-accelerator Experimental Physics

	FY 2010	FY 2011 Request	FY 2011 Feb	FY 2012 Request	FY 12 – FY 10
Non-Accelerator Physics	97,469	88,539	88,539	81,852	-15,617
Research	97,469	88,539	88,539	81,852	-15,617
Grants Research	21,708	22,556	19,853	21,417	-291
National Laboratory Research	44,933	43,923	47,826	46,435	1,502
Projects	30,828	22,060	20,860	14,000	-16,828
Current Projects	21,110	6,060	6,060	2,000	-19,110
DES	8,610	4,000	4,000	0	-8,610
SuperCDMS	1,500	0	0	0	-1,500
Daya Bay	11,000	2,060	2,060	500	-10,500
HAWC	0	0	0	1,500	1,500
Future Projects R&D	9,718	16,000	14,800	12,000	2,282

This program includes efforts at the Cosmic and Intensity Frontiers

- **There is a $17 million decrease in projects as Daya Bay, DES, and SuperCDMS-Soudan complete.**
- **LSST and dark matter experiments are in an R&D phase before starting Fabrication MIEs.**

The Cosmic Frontier – Program Guidance

Oct. 2009 - Received guidance from HEPAP (PASAG)

Recommended an optimized program over the next 10 years in 4 funding scenarios

August 2010 - Received guidance from Astro2010

Recommendations to DOE as part of a coordinated ground/space-based Dark Energy program.

Oct. 2010 - OECD Global Science Forum Astroparticle Physics Working Group

- A 2-year study of global coordination and planning of astro-particle physics experiments

→ recommended annual agency-level meeting to coordinate program (starts April 2011)

Cosmic Frontier Guidance
HEPAP (PASAG) Report - October 2009

Recommended an optimized program over the next 10 years in 4 funding scenarios:

- The panel laid out a prioritized program for an optimized cosmic frontier program over the next 10 years at various funding levels in the areas:

  Dark matter, Dark Energy, High Energy Cosmic- and Gamma-rays, and Cosmic Microwave Background

Defined Prioritization Criteria for Contributions to Particle Astrophysics Projects

- Science addressed by the project necessary (significant step towards HEP goals)
- Particle physicist participation necessary (significant value added/feasibility)
- Scale matters (particularly at boundary between particle physics and astrophysics)

Dark matter & dark energy remain the highest priorities

Guidance:

- Dark energy funding (recommended for largest budget portion) should not significantly compromise US leadership in dark matter, where a discovery may be imminent
- Dark energy and dark matter together should not completely zero out other important activities

Cosmic Frontier Guidance
Astro2010 Report – August 2010

Budgetary scenarios

- Levels given by agencies:
  - DOE, NSF – constant with inflation
  - NASA – constant dollars
- Level used by Astro2010 for recommendations:
  - DOE, NSF – doubling trajectory
  - NASA – constant with inflation

Recommended a coordinated ground/space-based Dark Energy program

- **Highest priority in space: WFIRST**
- **Highest priority on ground: LSST**

Recommendations to DOE :

- The optimistic (doubling) funding profile allows investment in:
  - LSST – DOE should partner with NSF
  - WFIRST – DOE should contribute (note that this is not a dedicated dark energy mission)
- **At lower funding level:**
  - **LSST is recommended as the priority because DOE role is critical**

- Other identified opportunities:
  - Contributions to NSF mid-scale experiments (2nd priority in ground-based) e.g. BigBOSS, CMB, HAWC experiments, etc.
  - NSF & DOE contribute as a minor partner (4th priority in ground-based) to a European-led AGIS/CTA ground-based gamma-ray observatory

Cosmic Frontier – Guidance

DOE HEP Considerations

The agencies (DOE, NASA, NSF) and OSTP have worked together on a coordinated response

Budgetary scenarios:

- Our current projections tend towards the lower funding amounts
- Do not have the same profile as assumed by Astro2010.

DOE OHEP Objectives:

- Contributions to select, high impact experiments with discovery potential
  - that address particle-astrophysics goals
  - where DOE HEP researchers and investments can play a significant role in and make significant contributions (PASAG recommended criteria)
- Achieve earliest, best, and most cost-effective U.S. dark energy and dark matter science results
- Partnerships with NASA and NSF and international collaborators as appropriate

Priorities

- Dark matter – direct detection experiments are a priority (not part of Astro2010 study)
- Maintain a leading U.S. role in dark energy research (Astro2010 recommendation)
- Other opportunities for contribution as funding permits

DOE HEP Strategy and Priorities

DOE HEP priorities are (per HEPAP/PASAG):

1. **Dark Matter (with NSF) - direct detection.**
   a. R&D and prototype detectors
   b. Down select to a few solid/liquid/gas phase detectors for next generation
   c. Choose technology for one or two ton-scale detectors

2. **Dark Energy – maintain a leading role**
   a. Ground-based program with NSF (as a major partner)
   b. Space-based experiments - will consider in the future

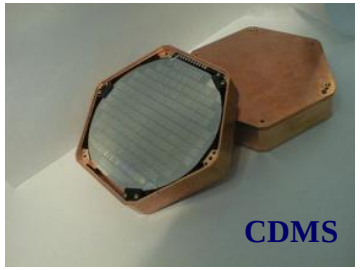
3. **Cosmic Rays/High Energy gamma-rays**
   a. Complete currently operating experiments
   b. Not participating in Auger North given current budget projections
   c. Will consider contributions to CTA-US in the future as appropriate

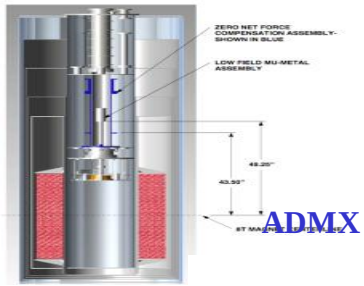
Particle Astrophysics - Budget

	FY 2010	FY 2011 CR	FY 2012 Request
TOTAL	**75,581**	**70,802**	**65,919**
Research	**55,753**	**54,002**	**52,419**
Univ/Grants Research	16,478	14,444	15,385
National Lab Research	35,505	32,608	30,582
Exp. Operations	3,500	6,950	6,452
Current Projects	**10,110**	**4,000**	**1,500**
DES	8,610	4,000	
SuperCDMS	1,500		
HAWC			1,500
Future Projects R&D	**9,718**	**12,800**	**12,000**

There is a decrease in project funding as DES and SuperCDMS complete. HAWC starts fabrication in FY12. LSST and dark matter experiments are in an R&D phase before starting MIEs.

Cosmic Frontier - Dark Matter (direct detection)





FY11 planning ~ $8M in research funding

Partnerships: All but ADMX are DOE/NSF partnerships. There are a few more that are mainly NSF-funded but with small DOE contributions (DMTPC, Xenon).

Future: We are working closely with NSF-PHY to coordinate reviews and funding of new efforts.

CDMS (Cryogenic Dark Matter Search)
SuperCDMS-Soudan fabrication 2009-2011 w/iZip detectors

LUX-350 (Large Underground Xenon) at Sanford Lab
Fabrication 2008-11; now commissioning on the surface

COUPP (Chicago Observatory for Underground Particle Physics)
COUPP-4 operating at SNOLab
COUPP-60 commissioning, operating at FNAL w/plans to go to SNOLab

ADMX (Axion Dark Matter eXperiment)
ADMX-I operations 2007-2009

Proposed Future Experiments: funds available for R&D and small fabrication – most collaborations are planning the next phase.

Cosmic Frontier - Dark Matter, cont.

Path Forward

Plan to pursue R&D on at least two technologies to search for dark matter.

Dark matter searches are very sensitive to backgrounds.

- Need to demonstrate excellent background rejection before choosing a technology.

FY 2012 request includes $3 million for R&D on the technologies.

Early Planning for a review process to select Generation-2 projects in the future.

Cosmic Frontier - Dark Energy

FY11 planning ~ $19M in research funding

DOE is funding operations for several supernovae studies:
Supernova Cosmology Project, Nearby Supernova Factory, QUEST, etc

Baryon Oscillation Spectroscopic Survey (BOSS)
- Primary survey on SDSS-III
- HEP, NSF-AST partner on the operations, which started Aug. 2009

Dark Energy Survey (DES)
HEP & NSF-AST partnership for new camera and data management system on the Blanco telescope in Chile
FY11: fabrication completes and integration/installation starts
FY12: start data-taking

Large Synoptic Survey Telescope (LSST)
- Aug. 2010 – Astro2010 recommended as top ground-based priority facility
- HEP and AST are working to coordinate our schedules and funding
- Agency Joint Oversight Group (JOG) set up; having biweekly meetings
- Mission Need Statement signed by the Director of the Office of Science for a Stage IV ground based dark energy experiment last week.

Cosmic Frontier - Dark Energy, cont.

Path Forward

JDEM R&D will be closed out this year.

NASA has the lead on WFIRST. We continue to talk to them.

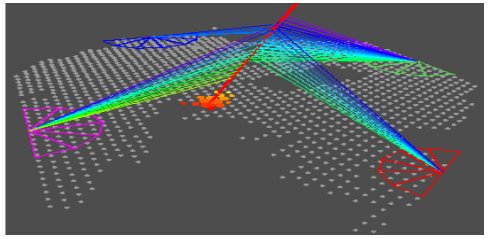
DOE HEP is supporting several people that were selected for the NASA's WFIRST Science Definition Team.

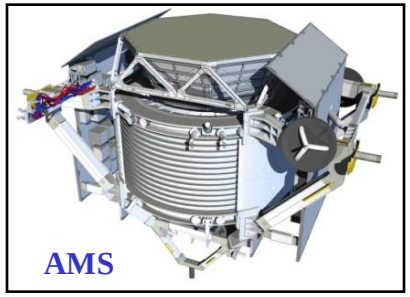
Depending on available funds and priorities in the program, HEP may consider efforts on future dark energy experiments – ground or space.

BigBOSS

- LBNL-led collaboration responded to National Optical Astronomy Observatory (NOAO) call for proposals for new instrumentation for Mayall telescope at Kitt Peak; NOAO reviewed and accepted the proposal and the labs are coordinating efforts and planning
- BAO method – stage IV dark energy experiment
- R&D funding is being provided (PASAG recommended)
- DOE - discussing with NSF and will plan review

Cosmic Frontier:
High Energy Cosmic-ray and Gamma-ray experiments





FY11 planning ~ $12M in research funding

VERITAS (Very Energetic Radiation Imaging Telescope Array System)
- DOE, NSF and Smithsonian Partnership at Whipple Observatory, Arizona
- Status: Science operations started in 2007 at Whipple Observatory in Arizona
- VERITAS-upgrade – NSF funded as an MRI in early 2010

Pierre Auger
- Large international collaboration; DOE and NSF are US partners; Fermilab hosts the Project Office
- Status: full science operations started in 2008 in Argentina
- Not participating in Auger North given current budget projections

FGST (Fermi Gamma-ray Space Telescope)
- DOE partnered with NASA on Large Area Telescope (LAT); launched June 2008
- SLAC hosted the LAT fabrication Project Office and now hosts the LAT Instrument Science Operations Center

→ **Bill Atwood (SLAC) and Peter Michelson (Stanford) and the FGST/LAT team have won the 2011 Bruno Rossi Prize in Astrophysics**

AMS (Alpha Magnetic Spectrometer)
- Large international collaboration; DOE funds the spokesman, Sam Ting
- Status: NASA plans to launch on the Shuttle on April 19, 2011

Cosmic Frontier:
High Energy Cosmic-ray and Gamma-ray experiments, cont.

Path Forward

HAWC (High Altitude Water Cherenkov) observatory
DOE and NSF partnership w/contributions from Mexico
- R&D in FY2011
- **Fabrication start in FY2012**

Future:
Will consider contributions to CTA-US in the future as appropriate.
- Discussions with collaboration ongoing

Cosmic Frontier - Other Efforts

Cosmic Microwave Background (CMB)

Small research and R&D efforts on a few experiments where we could make targeted contributions

Planck – updating the MOU with NASA to provide computing resources at NERSC for analysis

Other

Theory/modeling/simulations in support of experiments

Cosmic Frontier

➔ exciting discoveries and future opportunities!